A RELATIONSHIP OF SELECTED BODY COMPOSITION AND ANTHROPOMETRIC VARIABLES TO PERFORMANCE OF FREESTYLE AND BUTTERFLY STROKES IN SWIMMING

SHORT SYNOPSIS

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Certificate

1 hereby declare that the short synopsis **"**A RELATIONSHIP OF SELECTED BODY COMPOSITION AND ANTHROPOMETRIC VARIABLES TO PERFORMANCE OF FREESTYLE AND BUTTERFLY STROKES IN SWIMMING**"** being submitted in partial fulfillment of the requirement for the degree of Doctor of Philosophy in Physical Education under faculty of Physical Education of Lakshmibai National Institute of Physical Education,Gwalior during the academic year 2023-2024.

It is a bonafide record of original work carried out under the supervision of Dr. Meriline gogoi and has not been submitted in full or part to any other university or institute for a degree or diploma

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ABSTRACT

This study explores the relationship between selected body composition and anthropometric variables and their impact on the performance of freestyle and butterfly strokes in competitive swimmers. Swimming performance is influenced by various factors, including body fat percentage, lean mass, arm span, and body density. Understanding these relationships can provide valuable insights for athletes, coaches, and sports scientists aiming to optimize performance. The results are expected to highlight key body composition and anthropometric factors that enhance swimming performance in both freestyle and butterfly strokes. The findings will provide practical recommendations for training and conditioning programs, with the goal of improving performance outcomes in competitive swimmers. The study will also discuss potential limitations and delimitations, offering guidance for future research in this area.

CONTENTS

S.No.	Description	Page No.
1	Introduction	1-12
2	Literature Review	13 -17
3	Research Methodology	18- 20
4	Procedure for administration of test	21-23
5	Statistical procedure	24
6	References	25 -27

1 INTRODUCTION

Research is the systematic process of collecting and analyzing information to increase one's understanding of the happenings under investigation. It is the function of the researcher to contribute to the understanding to others for welfare of humanity and society. Research may be defined as a systematic approach towards the concerned problem or in generalizations of some theoretical formulation.

Research has given new dimensions to physical education with the use of science and modern technology. Research has helped sports scientists to record the athletic potential in early phases of life. New inventions are made in class management, size of class, grading and new records with the help of research. It has played a very important role in the field of growth and development, physical, mental, social and emotional aspects in order to know he attitude of society towards the sports science. Research has also developed norms in all games and sports for all age groups and for both sexes.

The improvement in swimming is brought about mainly by the refinement of technique. The techniques used by the swimmers today are not to be considered ultimate refinement as the scope of improvement is always there. No doubt, the application of the scientific methods and related allied disciplines of sports sciences like: Exercise Physiology, Kinesiology, Bio-mechanics, anthropometry, Sports Medicine and Sports Training which is contributory factors to refine the potentiality but on the other side the increased availability of infrastructure also enhanced the positive diversion of the society towards swimming and contributes towards wellbeing of an Individual.

Swimming performance is influenced by a complex interplay of physiological, biomechanical, and morphological factors. Among these, **body composition** and **anthropometric characteristics** have been identified as significant predictors of success, particularly in competitive strokes such as freestyle and butterfly (Ackland et al., 2003). These strokes demand high levels of muscular strength, coordination, and streamlined body positioning, all of which are closely associated with a swimmer's physical structure.

Anthropometry'' is a term originally intended to interface with various other disciplines, but is now generally understood to represent surface dimensional measurements of the human physique. These involve quantifying size, proportion, shape and composition, and occasionally gross function and maturation. These measures are applied to specific areas of interest such as growth, exercise, and sports performance or nutrition.

Body composition is a fundamental factor influencing athletic performance, particularly in sports such as swimming, where the interplay between buoyancy, hydrodynamics, and muscular efficiency can significantly impact results. In swimming, an optimal balance of body fat and lean muscle mass is essential to reduce drag, enhance propulsion, and maintain a streamlined body position in the water (Toussaint & Beek, 1992). The unique demands of swimming require athletes to not only possess strength and endurance but also maintain a body composition that supports efficient movement through a dense medium like water (Chatard&Collomp, 1990).

In recent decades, scientific interest in enhancing athletic performance has grown significantly. Researchers have identified anthropometric characteristics and body composition as vital elements influencing athletic success, especially in sports like swimming, where body proportions and tissue distribution directly impact buoyancy, drag, and stroke efficiency (Siders, Lukaski, & Bolonchuk, 1993)

While freestyle is the most widely used and studied stroke in competitive swimming, butterfly is one of the most physically demanding. Each stroke has unique kinematic patterns and energy demands. Despite this, few studies have focused on comparing how body composition and anthropometric variables affect performance in freestyle versus butterfly, particularly in a structured, quantitative manner. This gap presents a meaningful opportunity for research.

Anthropometric and body composition factors are often used to assess talent and monitor athlete development. In swimming, these measurements are crucial due to the water-based nature of the sport, where drag, buoyancy, and body positioning directly affect velocity. Studies have shown that swimmers with favorable body dimensions—such as longer arms relative to height, greater biacromial width, and lower body fat percentages—tend to perform better, particularly in sprint events (Zampagni et al., 2008).

While prior studies have explored general correlations between physique and swimming, limited research has focused specifically on the relationship between selected anthropometric and body composition variables and performance in **freestyle and butterfly**

strokes. These two strokes, although both power-intensive, involve distinct technical and biomechanical demands that may interact differently with physical attributes.

Anthropometry, aerobic capacity, and excellent respiratory capacity were essential aspects in improving athletes' performance(Anguera, Pereira, &Araújo, 2018)Sports experts agreed that athletes who had excellent anthropometry, aerobic capacity, and respiratory capacity plus a strong mentality tended to perform better. (Rüst, Knechtle,Knechtle, &Rosemann, 2013)

Despite an abundance of studies linking anthropometric variables and body composition to overall swimming success, limited research has explored these relationships in a stroke-specific context. Freestyle has been the dominant focus of performance modeling due to its prevalence in competitive events. Butterfly, though equally important in medley and sprint events, is less frequently studied in isolation.

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Statement of the problem

The purpose of this study will be to **a relationship of selected body composition and anthropometric variables to performance of freestyle and butterfly strokes in swimming**

Objectives of the study

On the basis of statement of the problem under taken for study the objectives of the study are as follows:

1. To determine how specific body composition variables, such as body fat percentage and lean body mass, correlate with performance in freestyle and butterfly swimming events.
2. Evaluate the Impact of anthropometric Variables on Swimming Efficiency
3. To identify which body composition and anthropometric factors most strongly predict successful performance in both freestyle and butterfly swimming.

4. To compare and contrast how body composition and anthropometric variables impact performance differently in freestyle and butterfly strokes.
5. To identify the profile of existing programmes and plans for promotion of swimming in India.
6. To draw the opinions and suggestions from the players and officials towards the development of ability of player by using these parameters.

Delimitation:

Since the study will be conceptualized with a very specific purpose for selected Subjects.

The research scholar confined this study to the following areas:

1. The study will be delimited to the swimmers of age category between 20 to 27 years.
2. The study will be further delimited to 40 male freestyle swimmers and 40 male butterfly stroke swimmers.
3. The present study will be delimited to those swimmers who has been participated in National level competition.
4. The data collection and analysis will be conducted over a specified period, likely within a single competitive season. Long-term changes in body composition and anthropometric variables or their impact on performance over multiple seasons will not be addressed.
5. Standardized tools and techniques will be used for measuring body composition and anthropometric variables, acknowledging their limitations and ensuring consistent application.
6. The study will be delimited to the 100 m freestyle and 100m butterfly strokes timming.
7. The study will be delimited to the selected body composition variables which includes
   Body density
   Lean Body Mass
   Body fat percentage
   Total body water
   Total fat mass
8. The study will be delimited to the selected anthropometric variables which includes
   Arm span
   Biacromial breadth
   Torso length
   Chest depth

Palm length

Foot length

Limitation

Environmental factors (e.g., water conditions, lane resistance) may influence performance but are not controlled.

Psychological and physiological states (e.g., fatigue, motivation) during testing are not accounted for.

Hypothesis

These are the assumptions of the Research Hypothesis of the study given below:

1. There will be a significant relation between arm span to freestyle and butterfly swimming performance.
2. There will be a significant relation between Biacromial breadth to freestyle and butterfly swimming performance.
3. There will be a significant relation between torso length to freestyle and butterfly swimming performance.
4. There will be a significant relation between chest depth to freestyle and butterfly swimming performance.
5. There will be a significant relation between palm length to freestyle and butterfly swimming performance.
6. There will be a significant relation between foot length to freestyle and butterfly swimming performance.
7. There will be a significant relation between body volume to freestyle and butterfly swimming performance
8. There will be a significant relation between lean body mass to freestyle and butterfly swimming performance
9. There will be a significant relation between body fat percentage to freestyle and butterfly swimming performance
10. There will be a significant relation between total body water to freestyle and butterfly swimming performance

11. There will be a significant correlation between total fat mass to freestyle and butterfly swimming performance

Definitions and explanations of terms

Anthropometric

is the science of measuring the size, weight, and proportions of the human body. It is primarily used to assess physical variation in populations, monitor growth and development, and support health, nutrition and ergonomic applications.

Arm span

Arm span refers to the measurement of a person's arm length from fingertip to fingertip when the arms are extended horizontally at shoulder level. It is used in anthropometry to assess body proportions and can be relevant in various fields such as ergonomics, sports science, and healthcare. Heyward, V. H., & Wagner, D. R. (2017).

Biacromial breadth

Shoulder width refers to the measurement across the shoulders from the outer edge of one shoulder to the outer edge of the opposite shoulder.Norton, K., & Olds, T. (2000).

Torso length

Torso length refers to the measurement from the seventh cervical vertebra (C7, the prominent bone at the base of the neck) to the top of the iliac crest (the upper edge of the hip bone). This measurement is significant in anthropometry for assessing body proportions.Heyward, V. H. (2010).

Chest depth

Chest depth refers to the measurement of the anterior-posterior distance of the chest, typically measured at the level of the nipples or the xiphoid process (the lowest part of the sternum). It is an important anthropometric measurement used in various fields such as sports science. Norton, K., & Olds, T. (1996).

Foot length

This is the length from the heel of the foot to the tip of the great toe. (Agnihotri AK et al,2007)

Palm length

Palm length refers to the measurement from the base of the palm (where it meets the wrist) to the tip of the middle finger when the fingers are fully extended.Goldberg, E. J. (2010).

Body composition

Refers to the proportion of different components that make up an individual's body weight.

Body density

refers to the mass of the body per unit volume. It is an important component in determining body composition, especially in sports like swimming, where buoyancy plays a critical role. Body density influences how an athlete moves through the water, with denser bodies typically being less buoyant and having more difficulty in maintaining optimal hydrodynamics.

Lean Body Mass

The weight of everything in the body except fat. It includes muscles, bones, organs, and other tissues. It is a key indicator of overall body strength and metabolic rate.

Body fat percentage

The proportion of fat tissue in relation to the total body weight. It is calculated as: Body Fat Percentage = (Fat Mass / Total Body Weight) × 100%. It provides insight into the relative amount of fat in the body.

Total body water

The total amount of water contained in the body. It includes intracellular fluid (within cells) and extracellular fluid (outside cells, such as in blood plasma and interstitial fluid). It is an important indicator of hydration status and overall health.

Total fat mass

Total fat mass is the absolute amount of fat in the body, usually expressed in **kilograms (kg)**

Total Fat Mass (kg) = Body weight (kg) × Body fat percentage (%)

Significance of the Study

This study may provide the following contributions.

1. Understanding the relationships between body composition, and anthropometry characteristics allows coaches and trainers to create more personalized training programs that maximize an athlete's potential.
2. Identifies how body composition and anthropometric factors directly impact freestyle and butterfly efficiency.
3. The result of the study will be useful as a screening tool in assessing and selecting the swimmers .
4. The study will also helpful for scanning the talents in swimming.
5. The observation of this study will be added new dimensions in the field of research in physical education.
6. The study may bring-out a suggested plan of action for the next generation of swimmers and for the promotion of swimming
7. This study may provide enthusiasm and interest among scholars for further research in the field of sports.

2 REVIEW OF LITERATURE

Marinhoet.al (2021). A Correlational Study between Anthropometric Variables, Muscle Strength, and Performance. Sport Mont Journal. 19. 10.26773/smj.211019. This study aimed to verify how the anthropometric characteristics and muscle strength levels of young swimmers of both sexes can influence sport performance on 50 m and 400 m freestyle events; 184 swimmers, aged between 13 and 16 years (mean±standard deviation: 14.64±0.80 years, 1.69±0.08 m height, 58.71±7.87 kg in body weight) participated in the study. The evaluation took place over two days. On Day 1, each subject was assessed with regard to anthropometric measures (i.e., body mass, height, wingspan); subsequently, the wingspan/height index and the body mass index, in addition to that, the strength of the lower and upper limbs were measured. On Day 2, swimming performances in 50m and 400m were evaluated, in the morning and afternoon, respectively. For the analysis of the results, the swimmers were divided into two groups, according to the competitive level (i.e., Group A and B). No anthropometric differences were found between male swimmers in the A and B Groups. However, female swimmers in Group A showed significant differences ($p<0.05$) in height and weight that positively affected performance. With regard to muscle strength, male Group A swimmers have a tendency towards higher values, with statistically significant differences in medicine ball throw. Differences in sports performance seem to be related to the biomechanical parameters of swimming, with higher values of the swimming index in male

swimmers and gestural frequency in female swimmers. The performance level of young swimmers seems to be determined by anthropometric and muscle strength variables.

Lima-Borges et.al (2022),Anthropometric requirements are different between swimming styles and swimming events. Thus, this systematic review aimed to verify the relationship between anthropometry and performance in different swimming styles.Methods. One hundred eighty records were identified, but 21 articles met the inclusion criteria. ResultsThe results showed the following frequencies of studies on anthropometric variables with the effect of interfering with the physical performance of swimmers: (57.1%) upper segment length, (51.4%) height, (23.8%) body mass, and (19.0%) length of lower segments. Therefore, height can influence gains with speed, being the most indicated variable for performance prediction, concomitant with the size of the upper segment. ConclusionNevertheless, some limitations should be highlighted, such as the lack of comparison between different styles and sizes of swimming events. Thus, although the findings included in this review indicate that the anthropometric variables related to performance differences in terms of swimming style, they do not show a variation considering the length of the tests.

Sokołowski, et.al (2022). Body composition and anthropometrics of young male swimmers in relation to the tethered swimming and kinematics of 100-m front crawl race The aim was to analyse the relationship of body mass and predicted muscle mass of body segments on swimming kinematics and tethered swimming indices, and further assess the influence of those indices on 100-m front crawl performance of adolescent male swimmers. METHODS In 19 volunteer swimmers (age: 13.5 ± 0.44 years, height: 168.6 ± 7.77 cm, body mass: 56.9 ± 10.57 kg), the predicted muscle mass of body segments was assessed with bioelectrical impedance analysis. The kinematic indices of swimming (stroke rate - SR, stroke length - SL, and stroke index - SI) were calculated from a video recording of a 100-m front crawl race. The strength indices (maximum and average value of force, average impulse per single cycle, force decline) were collected in a 30-second front crawl tethered swimming test. RESULTS The average tethered swimming force was positively correlated with surface swimming speed (0.505; $p \leq 0.05$). Indices of SL, SI were influenced by average impulse per single cycle (0.58, 0.55; $p \leq 0.05$), and further the SI was strongly correlated with most specified speed indices of the 100-m race (0.59; $p \leq 0.05$).

PourrahimGhouroghchiet.al (2021);Background: The relationship between anthropometrical and physiological parameters of elite young boys in breaststroke and butterfly swimming is essential. We aimed to investigate the relationship between anthropometrical and physiological characteristics with breaststroke and butterfly swimming time in elite swimmer boys. Materials and Methods: This study was a descriptive research, comprised of 122 elite young boy swimmers (age 12-13 years; height 1.540±8.24 m; weight 47.820±6.84 kg), who participated in the national championship of the country's selection in 2018 in Shiraz, Iran, and who had signed

the consent form Anthropometrical and physiological parameters were measured for 5 days. Pearson correlation coefficient was used to examine the relationships between variables. Results: There were significant negative relationships between supraspinatus fat (r=-0.461, P=0.009), right leg strength (r=-0.376, P=0.037), and static balance (r=-0.629, P=0.0001) with 50 m breaststroke time, between leg power (jump length)(r=0.448, P=0.015), and static balance (r=-0.529, P=0.003) with 100 m breaststroke time, between head circumference (r=-0.472, P=0.023), and leg power (jump length)(r=-0.454, P=0.030) with 200 m breaststroke time, between subscapularis fat (r=-0.434, P=0.012), and trunk flexibility (r=-0.350, P=0.046) with 50 m butterfly time, between trunk flexibility (r=-0.445, P=0.029), and100 m butterfly time. Whereas, there were significant positive relationships between leg action and reaction velocity (r=0.411, P=0.013) with 50 m breaststroke time, between dynamic balance (Internal)(r=0.368, P=0.050), and 100 m breaststroke time, between leg power (jump length)(r=0.511, P=0.002), and 50 m butterfly time, between triceps fat (r=0.489, P=0.015), and subscapularis fat (r=0.561, P=0.004), and dynamic balance (lateral)(r=0.424, P=0.039) with 100 m butterfly time. Conclusion: There was a significant relationship between anthropometrical and physiological characteristics with elite young boys in breaststroke and butterfly time.

Sammoudet al. (2023) The purpose of this study was to identify important anthropometric traits (such as ideal body height, limb-segment length, and girth/breadth ratios) associated with young swimmers' 100-meter front crawl performance. A total of 74 swimmers took part in the study: females [n = 33; age: 15.9 ± 3.1 years] and boys [n = 41; age: 18.1 ± 3.5 years]. To find important anthropometric traits linked to 100-meter front crawl swimming performance, we used a multiplicative allometric log-linear regression model. The primary findings showed that the 100-meter front crawl mean swimming speed performance was related to the following factors: biacromial breadth, foot length and ankle girth, length ratio = ([height/leg length]), and percentage of body fat. These results emphasize how crucial it is to evaluate young front-crawl swimmers' anthropometric traits in order to identify and develop their talent.

Alves et.al (2022) The purpose of this systematic review was to investigate the relationship between anthropometric characteristics, biomechanical variables and performance in the conventional swimming techniques in young and adolescent swimmers. A database search from 1 January 2001 to 30 June 2021 was done according to the PRISMA statement, with 43 studies being selected for analysis. Those manuscripts were divided in butterfly, backstroke, breaststroke and front crawl techniques as main categories. The results showed the importance of the anthropometric variables for the performance of the young swimmer, although there was a lack of variables common to the studies that analysed the butterfly, backstroke and breaststroke techniques. For the front crawl technique there is a consensus among studies on the advantage of

having higher height and arm span values, variables that concurrently with high body mass and lean body mass values, contribute positively to better stroke length and stoke index values.

Neogi et.al (2017) The aim of this study was to assess the role of gender on anthropometric and physiological characteristics of young swimmers. Twenty three young swimmers (15 boys: 15.28 ± 2.657 years old; and 8 girls 15.88 ± 2.181 years old) were evaluated. Various anthropometrics and physiological variables were selected. Results. The females were found to have a higher amount of fat mass (24.43 ± 4.542) while the males had a higher amount of muscle mass (22.39 ± 4.060) and fat free mass (83.72 ± 4.817) than females. The hand grip strength, trunk flexibility and relative back strength were also observed to be more in males and there exists significat relationship among these parameters as well as with glycogen, mineral, calcium content and muscle mass. No significant correlation was found between trunk flexibility and other parameters. There was a non-significant gender effect on BMI, right hand grip strength, trunk flexibility, body fluid content (total body water, extra cellular water and intra cellular water), body cell mass, total body calcium content, glycogen and mineral content. The BMI also had no differences with respect to gender. Although fat mass was found to be comparable, but fat free mass was found to be lower in male and female swimmers of the present study than their respective international counterparts. Intra cellular water is found to have negative correlation with almost all the parameters. The BMI also had no differences with respect to gender. Conclusion. Overall, there exists significant correlation in terms of the parameters between both the sexes. This kind of research helps athletes to precise information and feedback about their physical condition and effect of performance in order to adjust or continue their level of training.
Dopsaj, M.et.al(2020). Body Composition in International Sprint Swimmers The paper addresses relations between the characteristics of body composition in international sprint swimmers and sprint performance. The research included 82 swimmers of international level (N = 46 male and N = 36 female athletes) from 8 countries. We measured body composition using multifrequency bioelectrical impedance methods with “InBody 720” device. In the case of male swimmers, it was established that the most important statistically significant correlation with sprint performance is seen in variables, which define the quantitative relationship between their fat and muscle with the contractile potential of the body (Protein-Fat Index, r = 0.392, $p = 0.007$; Index of Body Composition, r = 0.392, $p = 0.007$; Percent of Skeletal Muscle Mass, r = 0.392, $p = 0.016$). In the case of female athletes, statistically significant relations with sprint performance were established for variables that define the absolute and relative amount of a contractile component in the body, but also with the variables that define the structure of body fat characteristics (Percent of Skeletal Muscle Mass, r = 0.732, $p = 0.000$; Free Fat Mass, r = 0.702, $p = 0.000$; Fat Mass Index, r = −0.642, $p = 0.000$; Percent of Body Fat, r = −0.621, $p = 0.000$). Using Multiple Regression Analysis, we managed to predict swimming performance of

sprint swimmers with the help of body composition variables, where the models defined explained 35.1 and 75.1% of the mutual variability of performance, for male and female swimmers, respectively. This data clearly demonstrate the importance of body composition control in sprint swimmers as a valuable method for monitoring the efficiency of body adaptation to training process in order to optimize competitive performance.

Yazdani et.al (2017)Objective: The aim of this study was to investigate the relationship between anthropometric characteristics and crawl and breaststroke performance in adolescent girl swimmers with an emphasis on ratio of length and width of limbs to the height of subjects.

Methods: Twenty adolescent female swimmers voluntarily participated in this study. Anthropometric variables, including height , length of thigh, leg, foot, arm, forearm and hand , arm span, widths of pelvic, shoulders, knees, wrists and ankles were measured using a tape measure and caliper. Then the ratio of length and width of limbs to the height of subjects was calculated. Pearson correlation test at a significance level of 0.05 was used for statistical analysis.

Results: Significant relationship were found between crawl record and subjects' height, thigh, arm and forearm lengths, arm span, shoulder width, the ratios of arm, palm and foot length to the height and ratio of arm span to height ($p<0.05$). Also, the relationship between breaststroke record and subjects' height, arm and thigh lengths, arm span, shoulder and palm widths, the ratios of forearm and thigh lengths to the height, ratio of shoulder girdle width to height and ratio of shoulder girdle to pelvic width were all found to be significant ($p<0.05$).

Conclusion: In addition to the effect of anthropometric characteristics such as height, arm, forearm, thigh lengths, arm span, palm and shoulder girdle widths on the performance of adolescent girl swimmers, the ratios of limb lengths and widths to the height and ratio of shoulder girdle to pelvic width were positively related with swimming record. Thus, it is recommended that to achieve better results in swimming talent, coaches consider the ratio of limbs to the height

Siders, W A et al.(1993) "Associations between competitive collegiate swimmers' somatotype, body composition, and swimming performance." Estimates of body composition and somatotype components in competitive collegiate swimmers were found to be related to sprint swimming performance. At the start of a competitive season, anthropometric and hydrodensitometric measurements were performed on 43 women and 31 men. Swimming performance (time in a competitive 100-yard swim of each swimmer's major competitive stroke) was significantly partially correlated (swim stroke was partialed out) with height (-0.466, $p < 0.01$), the mesomorphic (0.404, $p < 0.01$) and ectomorphic (-0.398, $p < 0.01$) components of somatotype, percent body fat (0.351, $p < 0.05$), and fat-free weight (-0.332, $p < 0.05$) among the women. percent body fat (0.351, $p < 0.05$), and fat-free weight (-0.332, $p < 0.05$) among the women correlations among the men. These findings indicate that measurements of body composition and

somatotype may be predictors of swimming performance in women but not in men. , but no significant correlations among the men. Twenty-three of the women and 21 of the men were also measured and timed at the end of the competitive season. Again, there were significant ($p < 0.01$) partial correlations (season and stroke were partialed out) between swimming performance and height (-0.766), fat-free weight (-0.657), body weight (-0.437), and the ectomorphic (-0.441) and mesomorphic (0.392, $p < 0.01$) components of somatotype in women, but no significant

RESEARCH METHODOLOGY

In this chapter selection of subjects, selection of variables, criterion measures, collection of data, experimental design, administrations of tests and statistical technique for the analysis of data have been described

SELECTION OF THE SUBJECTS

To achieve the purpose of the study 80 male swimmers will be selected 40 freestyle swimmers and 40 butterfly swimmers who participated in the national swimming competition from various states of India, age of the subject ranged between 20 to 27 years.

SELECTION OF THE VARIABLES

By considering the feasibility criteria and the specific purpose of the present investigation the following anthropometric and body composition variables will be selected.

Body composition variables

1. Body volume
2. Lean Body Mass
3. Body fat percentage

4. Total body water
5. Total fat mass

Anthropometry variables

1. Arm span
2. Biacromial breadth
3. Torso length
4. Chest depth
5. Palm length
6. Foot length

CRITERION MEASURE

The standard tests will be chosen to measure these variables tools will selected based on the standards followed.

Body composition variables

S L No	variables	Equipment and tools	Criterion measure
1.	Body density	Bioelectrical impedance analysis (BIA)	Kg/L
2.	Lean Body Mass	Bioelectrical impedance analysis (BIA)	Kilograms (kg)
3.	body fat percentage	Bioelectrical impedance analysis (BIA)	Percentage (%)
4.	Total body water	Bioelectrical impedance analysis (BIA)	Liters (L)
5.	Total **fat mass**	Bioelectrical impedance analysis (BIA)	Kilograms

Anthropometric parameters

S L No	variables	Equipment and tools	Criterion measure
1.	Arm span	Flexible measuring tape	centimeters
2.	Biacromial breadth	Large spreading caliper	centimeters

3.	Torso length	Flexible measuring tape	centimeters
4.	Chest depth	Wide spreading caliper	centimeters
5.	Palm length	Small sliding caliper	centimeters
6.	Foot length	Small sliding caliper	centimeters

ADMINISTARTION OF THE TEST

The objectives and importance of the study will be told to the players prior to the measurements to motivate them and to get their cooperation during the tests. The support of team managers and coaches will be taken to contact the players. The managers and coaches of the respective teams ensured the availability of players for the collection of data. All the bilaterally represented anthropometric measurements were taken on the right side. Posture of the players was checked regularly for accurate measurements during the anthropometric assessment. Standardized techniques and protocols for body composition and anthropometric measurements were used so that different studies may become comparable.

The criterion variable was the value of the absolute best result at 100 m freestyle and 100m butterfly stroke distance in 50 m pool, achieved in a given competitive micro cycle and expressed as FINA score

Body density

The mass to volume ratio of a person's body is referred to as body density. Usually, to calculate it, one divides the body volume (in liters) by the body mass (in kilograms). Because it may be used to measure the proportion of lean body mass (muscle, bones, and organs) to fat mass, body density is a crucial indicator of body composition. Body density affects buoyancy and hydrodynamic efficiency during swimming

Lean Body Mass

BIA estimates lean body mass, which includes muscle, bones, and organs, based on the resistance measurements and the known relationship between water content and lean mass.

If using a scale-based BIA, the participant should stand barefoot on the device. If using a handheld BIA, the participant should hold the electrodes with both hands while standing.

Body fat percentage

Place the BIA device on a flat, stable surface. Have the subject stand still with bare feet on the device's electrodes, or use hand electrodes if assessing upper body composition.

Total body water

BIA device capable of measuring TBW, which could be a handheld device or a scale with BIA features.Advise the participant to avoid eating a large meal, drinking excessive fluids, or engaging in vigorous exercise for at least 24 hours before the test

Total fat mass

Bioelectrical Impedance Analysis (BIA) is one of the most commonly used methods for assessing body composition, including fat mass. BIA estimates body fat percentage by measuring the resistance to a small, harmless electrical current as it passes through the body.

Arm span

Objective: To Measure the Arm Span

Instrument: Flexible Tape Test Measurement: arm span was measured with a flexible tape from of the tip of the middle finger on one hand to the tip of the middle finger on the other, with the individual standing with her back to the wall with both arms abducted to 90 degree, the elbows and wrists extended and the palms facing the front.

Scoring: The distance between the two far ends of hands is measured and recorded in centimeters.

Biacromial breadth

The participant should stand upright with their shoulders relaxed and arms hanging naturally by their sides. Ensure they are facing forward and maintain a neutral posture.

The acromion processes are the bony prominences at the top of each shoulder where the shoulder blade (scapula) meets the clavicle. Palpate and mark these points if needed.

Torso length

Aim: Length from C7 to top of the hip bone

Area: The C7 where shoulder slope meets top neck of the hip bone .

Method: Participants are asked to stand behind a subject that were to be estimated. Subject was asked to look straight ahead and stand normally. His C7 vertebrae was then located. The C7 where shoulder slope meets top neck and is easy to locate. In case it is not located, ask the subject to tilt their head slightly forward. The tape measure end was placed in the vertebrae and

was downward measured, flushing against the back, on their hips. Hands of the subjects was placed on their hips with their thumbs reached back. The top hip-bone is called iliac crest, in simpler terms is called the torso end. A line is imagined in the two thumbs and measurement was noted where measuring tape is crossing a line.

Chest depth

A wide spreading caliper calibrated in millimeters (mm)or centimeters. A measurement table or chart to record and interpret the results.

With the individual standing or sitting upright, locate and mark the xiphoid process and spine of the scapula on both sides of the body.

Palm length

Equipment Needed:

A sliding caliper with millimeter (mm) markings.

A flat surface to support the hand during measurement, such as a table or desk.

Locating the Landmarks : identify the anatomical landmarks for palm length measurement:

The distal wrist crease (where the hand meets the forearm).The tip of the middle finger (the longest finger).

Foot length

Aim: To measure length of the foot.

Landmark: The foot length was parallelly measured to the longer-axis.

Method: The measurement was produced on the upright topic, the right leg of his becoming slightly bent & pulled backwards therefore the body rested primarily on the left feet, what kind was being assessed. The caliper was horizontally positioned across the medial border of the feet. The fixed element of the external mouth of the caliper was put on on the pterion as well as the movable with the outer mouth was approximated with the acropodia as well as dimensions have been taken.

Statistical Techniques

In a study examining the relationship between body composition, anthropometric variables, and swimming performance in freestyle and butterfly strokes, various statistical techniques are used. Descriptive statistics summarize the data, providing means and standard deviations to understand trends in body composition and performance . and Suitable statistical technique will be applied according to data distribution

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